METHOD AND APPARATUS FOR REMOVING HEAT FROM A PROTECTION REGION WITHIN A TAMPER RESPONSIVE PACKAGE

BACKGROUND OF THE INVENTION

[0001] The invention relates in general to tamper responsive packages and more specifically to a method and apparatus for removing heat from a tamper responsive package.

[0002] Tamper responsive packages are used to physically protect devices and stored information by detecting tampering with the package. Tamper responsive packages are often formed by surrounding the electronic circuitry or device to be protected in a security envelope of a material that allows detection of any discontinuity, breaking or other mutilation of the material. A conventional tamper responsive package may include a thin material, often referred to as a tamper detection mesh, having a pattern of electromagnetic paths enclosing the protected circuitry. Tampering with the package results in damaging the material such that the change in the structure of the material is revealed in a change in the electrical characteristics of the material. These types of security envelopes typically require the entire protected circuit or device to be enclosed in a material having a high thermal resistance. In addition, conventional techniques often involve further covering the security envelope in substances having a relative high thermal resistance. Heat generated by the protected circuitry inside a high security envelope can not easily escape through the envelope, which can result in exposure of the circuitry to extremely high temperatures within the envelope. Such high temperatures often lead to poor circuit performance and can result in catastrophic failures of the circuit.

[0003] Therefore, there is need for an apparatus and method for removing heat form a tamper responsive package.

SUMMARY OF THE INVENTION

[0004] In an exemplary embodiment, a thermal conductor provides a thermal path from a protected region within a security envelope to an exterior region of the security envelope. The security envelope is formed around a housing that contains a protected device using a security material and allows the detection of physical tampering of the housing or the protected device. The thermal conductor conducts heat through a fold formed by overlapping sections of security material forming the security envelope.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 is a block diagram of a tamper responsive system including a protected device and a tamper responsive package in accordance with the exemplary embodiment of the invention.

[0006] Figure 2 is a diagrammatic representation of a perspective view of the tamper responsive system including a protected device and a tamper responsive package in accordance with the exemplary embodiment of the invention.

[0007] Figure 3 is a diagrammatic representation of a side view of the tamper responsive system including a protected device and a tamper responsive package in accordance with the exemplary embodiment of the invention.

[0008] Figure 4 is a flow chart of method of removing heat from a protected region within a security envelope of a tamper responsive package in accordance with the exemplary embodiment of the invention.

[0009] Figure 5 is a flow chart of a method of manufacturing a tamper responsive system in accordance with the exemplary embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] Figure 1 is a block diagram of a tamper responsive system 100 in accordance with the exemplary embodiment of the invention. The tamper responsive system 100 includes a protected device within a tamper restive package. A security envelope 102 is an envelope that surrounds a protected region 104 and allows the detection of physical tampering with anything contained within the protected region 104. As explained below, a suitable method of forming the security envelope 102 includes shaping a thin security material, such a tamper detection mesh, around the desired protected region 104. In the exemplary embodiment, the tamper detection mesh is shaped around a housing 106 that contains a protected device 108. A thin, flat sheet of security material is wrapped around the housing 106 such that two or more sections of material overlap to form folds 110.

[0011] A thermal conductor 112 provides a thermal path from the protected region 104 to an exterior region 116 of the security envelope 102. In the exemplary embodiment, the thermal conductor 112 thermally contacts the protected device 108 through a thermal connection having a minimal thermal resistance. A suitable technique of forming a thermal connection between the thermal conductor 112 and the protected device 108 includes directly connecting the thermal conductor 112 to the protected device 108. A thermal connection between the thermal conductor 112 and the protected device 108 can be formed using a conductive material having a low thermal resistance such as thermally conductive grease. The thermal connection between the thermal conductor 112 and the protected device 108 may be formed using the housing 106. For example, an adequate thermal connection between the protected device 108 and the housing 106 allows heat to flow from the protected to the housing 106. The thermal conductor 112 can be thermally connected to the housing 106 to provide a thermal path from the housing 108 within the protected region 104 to the exterior region 116 and thereby providing a thermal path from the protected device 108 to the exterior region 116.

[0012] The heat generated within the protected region 104 is channeled through an opening in the housing 106 and the fold 110 to the exterior of the security envelope 102. In the exemplary embodiment, the heat is transferred to a heat sink 118 through conduction and dissipated to the air of the exterior 116 of the security envelope 102 through convection. The heat sink 118 is drawn using a box having dashed lines to illustrate that the heat sink 118 may not be required in certain instances. Other suitable techniques of dissipating the heat include dissipating the heat directly from the thermal conductor 112 to the air through convection. Further, the thermal conductor 112 may be shaped to include heat fins to improve heat dissipation to the air. In some implementations it may be desirable to use cooling fluids other than air. Other gases may be used for convection or liquid cooling may be used in some instances.

[0013] Figure 2 and Figure 3 are diagrammatic representations of a perspective view and a side view of the tamper responsive system 100 in accordance with the exemplary embodiment of the invention. Figure 2 and Figure 3 are provided for illustrative purposes and are not necessarily drawn to scale. In the exemplary embodiment, the tamper responsive system 100 includes a protected device 108 within a tamper responsive package formed by the security envelope 102, housing 106 and the thermal conductor. Those skilled in the art will recognize the various additional elements that may be used in a tamper restive package. For example, wires or ribbon cables may be attached to the protected circuit and other circuitry or devices within the tamper responsive package. The protected device is located in a protected region 104 within the security envelope 102 formed from a security material. In the exemplary embodiment, the security envelope 102 is wrapped around the housing 106 which includes the protected device 108.

[0014] In Figure 2, the exemplary tamper responsive system 100 is drawn with a cut away section to illustrate the inside of the housing 106. The cross hatched area illustrates the exposed housing 106 underneath the security envelope 102. In the

exemplary embodiment, therefore, the entire housing 106 is covered by the security envelope and no portion of the housing 106 is visible from the exterior region 116.

[0015] The security envelope 102 may be formed in a variety of ways using one or more sheets of security material. In order to completely cover the housing 106 with a planer sheet of security material, the security envelope 102 is formed to include one or more folds 110 where at least one section of security material overlaps a second section of security material. One simple analogy of the forming of the security envelope 102 around the housing 106 includes the wrapping of box with gift wrapping paper.

[0016] The protected device 108 is positioned within the housing 106 and is secured in accordance with known techniques. In the exemplary embodiment, the protected device 108 is soldered or otherwise attached to a circuit board (not shown). The protected device 108 may be one or more devices and may include any combination of integrated circuits (ICs), circuits, components, memory chips, encryption devices, or any other type of electronic device requiring physical security. As suitable example of a protected device 108 includes a cryptographic processor.

[0017] The tamper responsive package provides physical security by detecting physical tampering with the security envelope 102, the housing 106 or the protected device 108. In accordance with known techniques, tampering is detected by observing a change in electrical characteristics of the security envelope 102. For example, if an unauthorized party attempts to drill through the housing 106 to access the protected device 108, the disruption of the tamper detection mesh used to form the security envelope 102 is detected by a sensing circuit. A sending circuit (not shown) detects that a tampering has occurred if the tamper detection mesh is cut, broken, drilled, punctured, mutilated or altered in any way. The security material of the security envelope 102 is adhered to the both the housing 106 and to the thermal conductor 112 in the exemplary embodiment. Any attempt to separate the security material from the either the housing 106 or the thermal conductor 112 will result in detection by the

sensing circuit. The detection by the sensing circuit may invoke a variety of counter measures such as erasing the contents of the protected device 108, destroying the protected device 108 or otherwise disabling the protected device 108 to secure the information to be protected.

[0018] As explained above, the thermal conductor 112 is thermally connected to the protected device 108. The protected device 108 may have housing or cover formed from any one of several materials such as metal or plastic. Those skilled in the art will recognize the various techniques that can be used to form the thermal connection. The thermal conductor 112, for example, may be soldered to a casing or housing of the protected device 108. Other techniques include using thermal conductive grease or physically securing the thermal conductor 112 to the protected device 108 with fasteners.

[0019] In the exemplary embodiment, the thermal conductor 112 is a section of copper tape that forms a thermal connection with the protected device 108 and is threaded through the fold 110. The thermal conductor 112 may be formed using various thermally conductive materials and may have a variety of shapes and dimensions suitable for channeling heat from the protected device 108 through the fold 110.

[0020] In the exemplary embodiment, the thermal conductor 112 is guided through the housing 106. As shown in Figure 3, an opening 114 in the housing 106 provides a thermal path for the thermal conductor 112. A suitable opening 114 may be formed by drilling a hole or cutting a slit having dimensions adequate for the thermal conductor to pass through without contacting the housing 106.

[0021] Therefore, in the exemplary embodiment, the thermal conductor 112 forms a thermal pathway from the protected region 104 to the exterior region 116 by channeling heat generated by the protected device through a fold 110 in the security envelope 102 formed around the protected region 104. Heat can be removed from the

protected device 108 without disturbing the integrity of the security envelope 102. The performance of the protected device is improved while reducing the possibility of a catastrophic failure.

[0022] Those skilled in the art will recognize the other embodiment and modifications based on the teachings herein. For example, the thermal conductor may provide a thermally conductive path from the protected region 104 to the exterior region 116 without directly contacting the protected device 108. Such an implementation may be desired where the housing is thermally conductive and the protected device is thermally connected to the housing 106. Heat generated by the protected device is absorbed by the housing and is dissipated from the protected region to the exterior region 116 through the thermal conductor 112.

[0023] Figure 4 is a flow chart of a method of removing heat from a protected region 104 within a tamper responsive package in accordance with the exemplary embodiment of the invention. At step 402, heat is channeled from the protected device 108 through a thermal connection between the protected device and the thermal conductor 112. In the exemplary embodiment, conduction is used to transfer the heat directly from the protected device to the thermal conductor 112. Substances such as thermally conductive grease can be used to transfer heat the protected device 108 to the thermal conductor 112.

[0024] At step 404, the heat is channeled from the protected device 108 through a fold in the security envelope 102 to the exterior region 116 of the security envelope 102. The thermal conductor 112 conducts the heat from the protected device 108 and between the overlapping sections of security material forming the fold 110. In the exemplary embodiment, a section of copper tape (112) threaded through an opening 114 within the housing 106 and between the sections of tamper detective mesh (102) provides a thermal path to the exterior region 116 for the heat. In some instances, multiple thermal conductors 112 may be used transfer heat to the exterior region 116.

[0025] At step 406, the heat is dissipated to the exterior region. The heat may be dissipated though natural convention or forced convention to the air within the exterior region 116. Further, the heat may be dissipated to a heat sink within the exterior region 116.

[0026] Figure 5 is a flow chart of a method of manufacturing a tamper responsive system 100 in accordance with the exemplary embodiment of the invention. At step 502, the protected device 108 is mounted on a circuit board. In the exemplary embodiment, the protected device 108 and other components are soldered or otherwise secured to the circuit board.

[0027] At step 504, the thermal conductor 112 is attached to the protected device 108. In the exemplary embodiment, the thermal conductor 112 is a section of copper tape having a pre-applied adhesive allowing the tape to be attached to the protected device by joining the adhesive side of the copper tape to the protected device 108. Other methods of attaching the thermal conductor include soldering, gluing, an fastening the thermal conductor to the protected device 108. Further, a thermally conductive grease can be applied between the thermal conductor 112 and the protected device 108 to improve heat transfer from the protected device 108 to the thermal conductor 112. In the exemplary embodiment, ribbon cable providing is connected to the ports of the protected device 108 and other components.

[0028] At step 506, the thermal conductor 112 is guided through an opening 114 in a housing 106. In the exemplary embodiment, the ribbon cable is guided through either the opening 114 or through another opening in the housing 106.

[0029] At step 508, the protected device 108 is enclosed by the housing 106. In the exemplary embodiment, the housing 106 is a metal enclosure often referred to as a "metal can" that is secured to the circuit board.

[0030] At step 510, the housing 106 is enclosed with the security material to form a security envelope 102 having a fold 110 such that the thermal conductor 112 is

positioned between the sections of security material forming the fold 110. One or more planar sheets of security material such as tamper detection mesh are wrapped around the housing 106. The fold 110 is positioned to allow the thermal conductor 112 and the ribbon cable to pass through the security envelope 102 to the exterior region 116.

[0031] At step 512, the security envelope 102 is encased in a potting material. The potting material provides a hard shell or enclosure that provides an additional deterrent to tampering as well as providing a mechanism for firmly securing the security envelope 102 to the housing 106. An epoxy can be used as a potting material.

[0032] In the exemplary embodiment, the various steps described in reference to Figure 5 are performed in the order presented above. In some instances, the steps may be performed in other sequences. For example, the thermal conductor may be guided through the opening in the housing after the protected device 108 is enclosed by the housing 106.

[0033] Clearly, other embodiments and modifications of this invention will occur readily to those of ordinary skill in the art in view of these teachings. Therefore, this invention is to be limited only by following claims, which include all such embodiments and modifications when viewed in conjunction with the above specification and accompanying drawings.

WHAT IS CLAIMED IS: